Micro Controller based Current Fed Dual Bridge DC-DC Converter

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Abstract-**Here emphasis is to realize a new isolated current –fed pulse width modulation dc-dc converter – current fed dual- bridge dc –dc converter – with small inductance and no dead time operation Previously current fed full bridge dc-dc converter were used for few applications. There are few draw backs in current fed full bridge converter. The output of the dc choppers with resistive load is discontinue and contains harmonics .The ripple content is normally reduced by an LC filters But concentrating now current fed dual bridge. The new topology has more than 3 x smaller inductance than that of current –fed full-bridge converter , thus having faster transient response speed Compared with the conventional Full bridge Converter, the dc to dc converter with the new topologies have lower input current ripple, less stress on power switching components and smaller output filter inductor.**

Index Terms-**Current-fed, dc-dc converter, deadtime, dual-bridge,**

1.1INTRODUCTION

The main reason why AC electricity was accepted as the form of choice for the modern electric power system is the magnetic transformer. The inability to conveniently change voltage levels became one of the major drawbacks of Edison's early DC system concept. The DC transformer can be a device that, like its AC counterpart, provides lossless transfer of energy between circuits at different voltage or current levels which become useful to adopt DC system in place of existing AC systems. In power electronics the DC – transformer is realized as a DC – DC converter. Energy is transferred between two DC circuits at different voltage and current levels.

Importance ofDC – DC Conversion

DC to DC conversion is significant in electronic circuit applications and is becoming increasingly important. Modern fixed- output DC power Supplies find their way into products ranging from home appliances to industrial controllers. A DC-to-DC converter is a device that accepts a DC input voltage and produces a DC output voltage. Typically the output produced is at a different voltage level than the input. In addition, DC-to-DC converters are used to provide noise isolation, power bus regulation, etc. This is a summary of some of the popular DC-to-DC converter topologies: Today most supplies are built with DC to DC converters. The incoming AC is rectified directly with a simple diode circuit and then the high level DC is converted to desired levels. Modern power supplies of this type range from 2V output for special logic up to 500V or more for industrial applications. Others are intended to handle the 12V level used in many telephone networks. Converters for 12V to 24V support analog power supply applications and are also used in many commercial designs for automobiles. The output of the oscillator is fed to main output transformer through the MOSFETS driving stage. This is a step-up transformer, which generates 30V AC from a DC source of 12V. Contemporary research in DC-DC power conversion is strongly motivated by theneed to increase performance while reducing size and maintaining or improving efficiency.

To combat these difficulties, new circuit topologies and system architectures can beused. Replacing hard-switched square-wave topologies with resonant, soft-switchedconverters allows high frequency converter designs that take advantage of techniquesemployed in tuned radio frequency power amplifiers. To solve the problem of controlling thishigh-frequency DC-DC converters, a new architectural approach will be employed whichpartially decouples the problems of efficient power conversion and controlled power delivery.In this project work, the PWM oscillator is designed to produce 20 KHz approximately,because the transformer core (Ferrite core) used in this project work can with stand up to 20KHz only.

Problems with High-Frequency Power Conversion

Whereas at low frequencies conduction losses are generally dominant, at highfrequencies two other loss mechanisms, switching loss and gating loss, must also beconsidered. In addition, traditional control strategies for low frequency converters areimpractical at high frequencies. Finally, implementing passive components compatible withefficient power processing at high frequency is often difficult; inductors are of particularconcern, as there exist few permeable materials whose performance is acceptable forapplication in high frequency power conversion.

Switching Loss

Switching loss arises from the fact that no practical active element can turn on or off instantaneously: there is some interval during which the device must traverse the region between the on and off states. During this time, the device both conducts current and dropsVoltage, dissipating power. To ameliorate switching losses, zero-voltage switching topologies are often employed. In these topologies, a continuous resonating action is used toensure that switches only change state when supporting little or no voltage. While ZVS canbe advantageous when applied to DC-DC conversion at full load, it becomes a problem atlight load: since the losses accompanying resonant operation are present at all loadconditions, efficiency when delivering only a fraction of full power is severely reduced.

Gating Loss

Gating loss is a result of the fact that turning any active device on or off involves atransfer of energy. In a MOSFET, for example, the gate capacitance must be charged to turnthe device on and discharged to turn it off. In a switching scheme where the gate terminal isCharged from the supply and discharged into ground, power loss proportional to frequencyresults. By employing resonant structures in driving the gate, energy can be recovered andreused in subsequent cycles. In the simplest of such circuits, the energy transferred onto thegate capacitor is transferred off and stored on an external inductor until the next switching.Cycle; in this way, energy is only lost in conduction. In effect, a resonant gate driver is itselfan RF amplifier; thus, the benefits of resonant gate drive can often be most fully developedby using a cascade of resonant converters, one driving the next.

Control Strategies

Control strategies employed at low frequencies are not easily adapted to efficient highfrequency topologies. Since such strategies often required direct manipulation of theharmonic content of operating waveforms, they are generally incompatible with ZVS andresonant gate drive topologies. Regulation can be achieved by other techniques, such asfrequency control; even so, realizing regulation over a wide load range becomes increasinglydifficult as frequencies increase, as do considerations of converter dynamics and thecomplexity of implementing control circuitry.The purpose of this project work is to demonstrate the operation of DC – DCconverter. The main advantage of this converter is, the output voltage of this converter can beprogrammed, so that the required voltage can be obtained. The basic oscillator of theconverter is designed with PWM (Pulse Width Modulation) IC, for this purpose 3524 IC isinternal oscillator; with the help of two external components i.e., Resistor andcapacitor connected to Pin No.6 and 7of the IC; frequency can be varied from 1Hz to50KHZ. The required frequency is 20 KHz approximately.

The oscillator frequency can be easily set by an external resistor. The output of theoscillator is fed to main output transformer through the MOSFETS driving stage. This is astep-up transformer, which generates 30V AC from a DC source of 12V.The selection of inverter transistors or power MOSFETS and the design of theinverter transformer depend on the specific requirement of the inverter. If the accuracy ofthe specification is more or the tolerances are higher, it is more difficult to design and the costalso increases considerably. DC-to-DC converters are usually designed for the highestpossible efficiency but if the output and frequency stability are higher, it simplicity. Some ofthe specific requirements of an inverter or converter may be listed as follows;

_ Input Voltage and its variation
_ Nominal output voltage and its regulation
_ Output frequency and its stability
_ Output power
_ Type of load and power factor
_ Overall efficiency at various loads
_ Size and weight

The controller used in this project is ATMEL 89C51, and this is 40pin IC having 32I/O lines. The ATMEL AT89C51 is a low power, higher performance CMOS 8-bitmicrocomputer with 4K bytes of flash programmable and erasable read only memory(PEROM). Its high-density non-volatile memory compatible with standard MCS-51instruction set makes it a powerful controller that provides highly flexible and cost effectivesolution to control applications.Micro-controller works according to the program written in it. The program is writtenin such a way, so that the Micro controller can read and it can store the information receivedfrom the keyboard. According to the received information from the keyboard, the Microcontroller energizes the corresponding relay. These relay contacts are used to control thereference voltage of variable regulator. Micro-controllers are "Embedded" inside some other device so that they can controlthe features or actions of the product.

2. FULL BRIDGE DC-DC CONVERTER.

The novel soft-switching topology for DC–DC converters for Regulated- Outputapplications and for Constant–Input, Variable Output applications is discussed by (AyyanarR. et al, 2001). The features here are Zero voltage switching down to no–load without seriousconduction loss penalty, constant frequency operation and near-ideal filter waveforms. Theconverter operation is analysed for typical Switched–mode power supply applications i.e.,fixed and well– regulated output voltage and for battery chargers with a PFC pre-regulatori.e., for fixed–input, variable output applications.

Isolated converter topologies:

Isolated converter topologies provide advantages in applications requiring largevoltage conversion ratios. Transformer isolation can reduce switch and diode device stressesand allows multiple windings or taps to be used to for multiple converter outputs. The full bridgeis a popular design for both buck and boost applications and has become a basis fornumerous resonant zero voltage and zero current switching (ZVS, ZCS) schemes. Often inhigh power applications a phase shift modulation (PSM) switching scheme is used to achieveZVS and/or ZCS transitions through the interaction of converter parasitic energy storageelements. Another advantage for using the full bridge converter is the fact that when power application are requested the full bridge converter can act as a modular block and thatit is possible to stack up . For this purpose the chosen topology for the converter to be used in this application is a Full bridge phase shifted PWM converter. Higher power application are requested the full bridge converter can act as a modular block and thatit is possible to stack up. For this purpose the chosen topology for the converter to be used inthis application is a Full bridge phase shifted PWM converter.

FB-Converter Model in DCM & CCM

In order to reduce the size and the weight of magnetic components it is desirable toincrease the switching frequency for DC-DC converters. When conventional PWMconverters are operated at high frequencies, the circuit parasitic has negative effects on theconverter performance. Switching losses increase in high power applications and snubbersand/or other means of protection are required, which introduce significant losses and lowerthe efficiency. In the case of the conventional full bridge converter, the diagonally oppositeswitches (Q1 and Q2, or Q3 and Q4) are turned on and off simultaneously.

Operation:

In the FB-PWM converter, when all four switches are turned off, the load current freewheels through the rectifier diodes. In this case the energy stored in the leakageinductance of the power transformer causes severe ringing with MOSFET junctioncapacitances. This creates the need for using snubbers that increase the overall lossesbringing down the efficiency. If snubbers are not used, the selection of the devices becomesmore difficult as the voltage rating for these switches has to be much higher. As the voltagerating goes up, so do the conduction losses and as a result the overall losses increase. At thesame time the cost increases as well. In order to minimize the parasitic ringing, the gatesignals of Q2 and Q4 are delayed (phase-shifted) with respect to those of Q1 and Q3, so thatthe primary of the transformer is either connected to the input voltage or shorted.The leakage inductance current is never interrupted, thus solving the problem of parasitic ringing associated with the conventional full-bridge PWM converter.

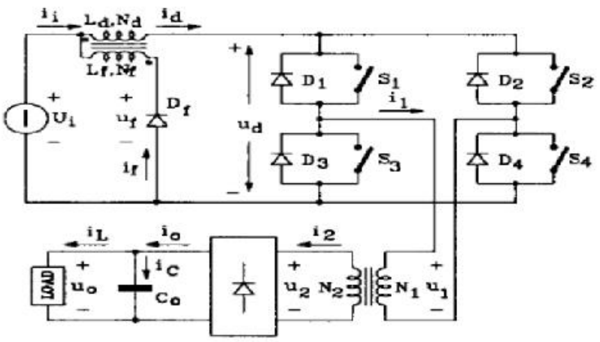

Fig 2.1 basic converter scheme

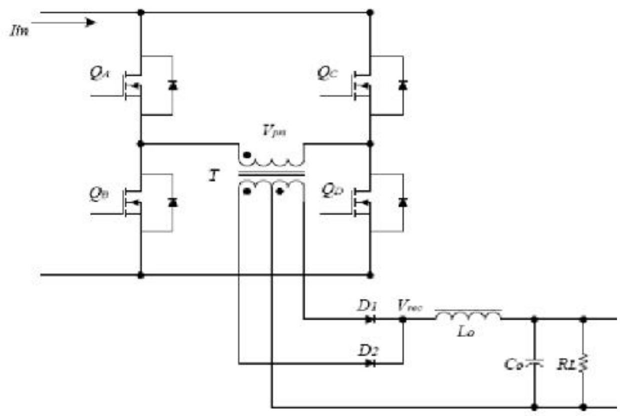

Fig 2.2 schematic of power stage of full bridge converter

Besides preventing switches A and B (or C and D) from conducting simultaneously,this dead time is essential for conventional dual-end (half- and full-bridge.) converters to obtain a regulated output voltage when the input voltage changes. During the dead time, theinput current becomes zero; this discontinuity causes a large input ripple current. Thus, largeinput filters must be used to satisfy the conducted EMC requirements. This dead time alsoneeds a large output inductor to smooth the output voltage and limit the ripple currentthrough it. The large output inductor slows the output response time.

Lower output inductance value improves the output transient speed and reduces theoutput filter size, thus improving power density (power-to-volume ratio) of the DC-DCconverter. Several methods, for example, magnetic transformer tapping and implementationwith two transformers can be used to realize no dead time topologies.Figure 2.3 shows their typical waveforms of input current inn and the voltage Vpacross the primary winding of the transformer. This research presents two topologies of nodead time DC-DC converters. They are the Dual-Bridge DC-DC converter and the Dual-Bridge converter with ZVS. The new topologies are characterized by no dead time propertyand have significantly reduced output filter inductors.

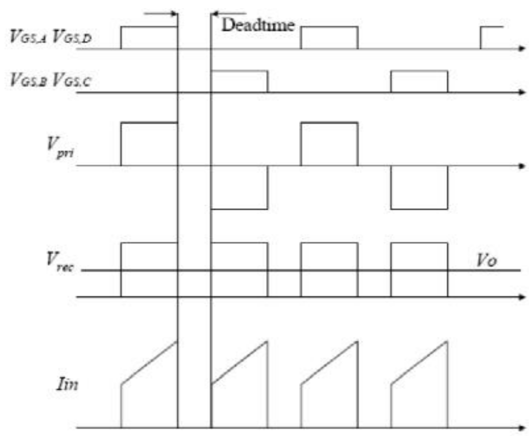

Fig .2.3 wave forms of full bridge converter.

CCMand DCM Operation

DCM occurs with large inductor current ripple in a converter operating at light loadand containing current-unidirectional switches. Since it is usually required that convertersoperate at no load, DCM is frequently encountered. The properties of the converter changeradically in the discontinuous conduction mode. The conversion ratio M becomes loaddependent and the output impedance is increased.

The ripple magnitude depends on the applied voltage, the inductance value, and onthe transistor conduction time *DTs*. However, the ripple does not depend on the loadresistance *R*. The inductor current ripple magnitude varies with the applied voltages ratherthan the applied currents. If the load resistance is increased so that the DC load current isdecreased, the ripple magnitude *L i.* will remain unchanged. If the load resistance increasesthere will be a point when *L i I.* = is reached. As the load is decreased, the diode currentcannot be negative therefore the diode must become reverse biased before the end of theswitching period. This is what is known as discontinuous conduction mode (DCM).

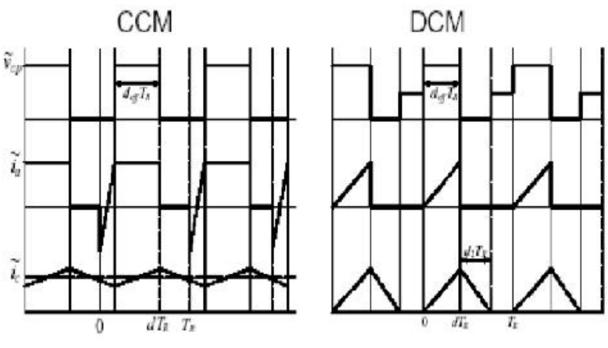

Fig 2.4 wave forms of CCM & DCM FB converter

3. DUAL BRIDGE DC-DC CONVERTER AND BLOCKDIAGRAM AND ITS BRIEF DESCRIPTION

Dual Bridge DC-DC Converter

With the wide spread use of low voltage microprocessors as well as various low –voltage ICs, research on DC – DC converters with low voltage and high current output hasbecome increasingly important. There has been a recent trend in industry to use the bridgetopologies in lower conversion power ranges of 100W to 300W and lower input voltage inthe tens of volts. This chapter deals with the circuit description and operation of the twoTopologies of Dual bridge DC to DC converter. Also, the comparison of the circuit withConventional full bridge is done and the Fourier spectra of both the circuits are presented.

Topologies to Prevent Dead Time

The topologies used to prevent dead time are the two transformer implementationwith two diode output rectifier and the tapped primary full bridge circuit.

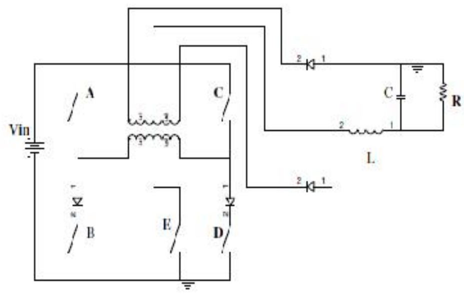

Figure 3.1 Full Bridge Circuit with tapped primary winding

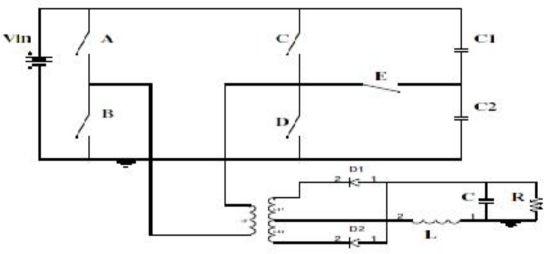

Figure 3.2 Principle illustration of Dual Bridge Converter

Advantages of No Dead Time Operation

The topologies with no dead time during the operation result in energy beingcontinuously transmitted from DC source to the output load in the whole switching period.Because of the lower input ripple current in a no dead time DC – DC converter, theconducted EMI filter is relatively smaller. Lower output inductance value improves theoutput transient speed and reduces the output filter size, thus improving power density (powerto volume ratio) of the DC – DC converter

Circuit Description:

The switches S1, S2, S3 and S4 form a Full bridge converter. The switches S1, S2 andcapacitors C1, C2 form a Half bridge converter. Dual - bridge shown in Figure 3.3 is the.Combination of the two bridges. The two bridges are connected by S5 for bidirectional controlof current. Suppose the converter works in steady state and its output inductor current isunder continuous conduction mode. The high frequency transformer is modelled by the following: the transformer has theturn's ratio n, its total stray inductance Lσ is the sum of the primary stray inductance and thesecondary stray inductance reflected across the transformer to the primary. The magnetizinginductance Lm is much bigger than the leakage inductance.Figure 3.3 Dual bridge DC-DC converters.

Circuit:

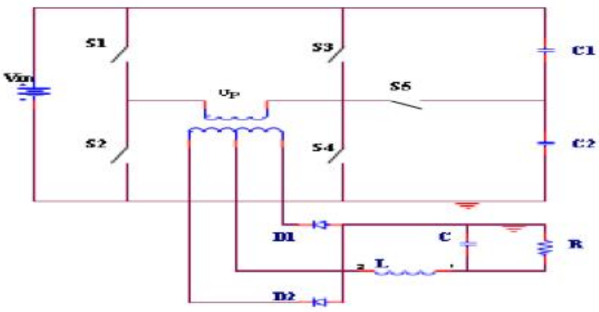

Figure 3.3 Dual bridge DC-DC converters

Circuit Operation

In mode 1 as in Figure 3.4(a) the switches S1 and S4 are turned on. TheLoad Current flows through S1, load and S4. The voltage across the primary side oftransformer, Vp = Vin and voltage across the secondary side of transformer, Vs=nVin. Inputcurrent iin increases and equals the primary winding current ip.

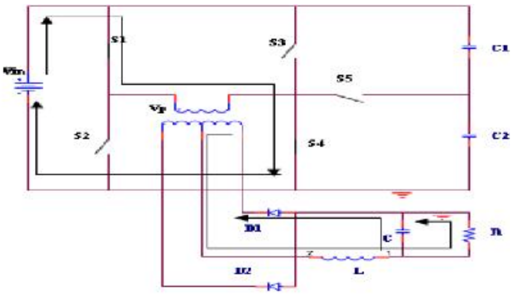

Figure 3.4(a) Mode 1($t_0 < t < t_1$)

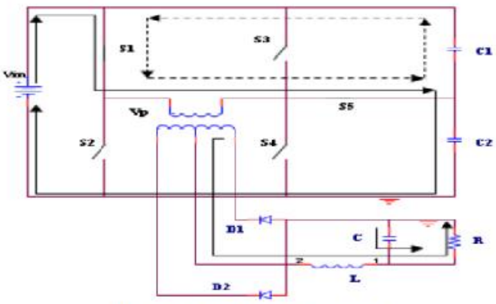

Figure 3.4(b) Mode 2 ($t_1 < t < t_2$)

In mode 2 as in Figure 3.4. (b) The switches S4 is off and S5 is on. The current ip flowsthrough S1, load and S5 charging C2 while the capacitor C1 discharges. The voltages, Vp =Vin/2 and Vs = nVp = nVin/2. At t2, S1 and S5 turn off and S2 and S3 turn on.

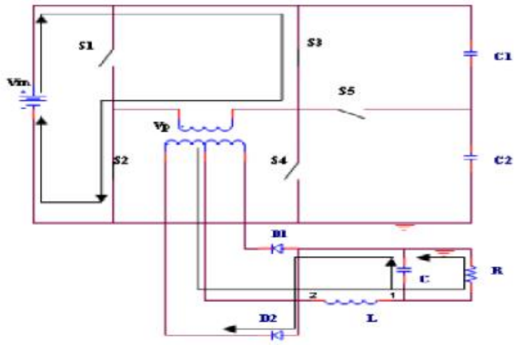

Figure.3.4(c) Mode 3 ($t_2 < t < t_3$)

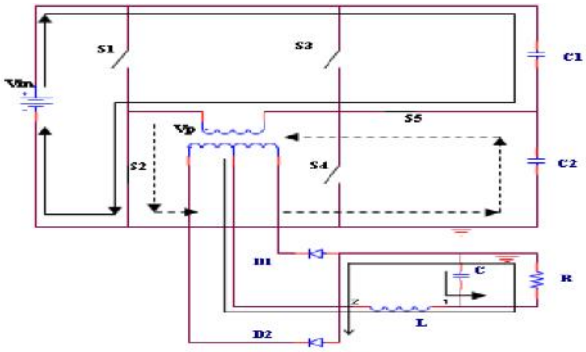

Figure 3.4(d) Mode 4 ($t_3 < t < t_4$)

The mode 3 operation as in Figure 3.4(c) is in symmetry with time intervalt0 < t< t1 and the voltage, Vs= nVp=-nVin. The operation of mode 4 as in Figure 3.4(d) is insymmetry with time interval t1< t< t2 and now the voltage, Vs= nVp =-nVin/2.

Idealized Waveforms

The ideal waveforms of the Dual Bridge converter are shown inFigure 3.5

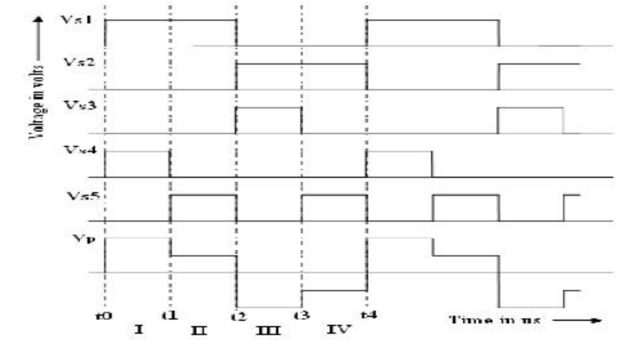

Figure 3. 5 Idealized waveforms of Dual bridge DC-DC converter

The control signals of the switches S1 to S5 are as shown. VS1 and VS2 are two 50%duty ratio complementary control signals of S1 and S2. VS3 and VS4 are control signals ofswitches S3 and S4 with duty ratio, D and switching frequency, f. VS5 operates at f0 = 2f (T0 =T/2). The values of D and (1-D) are obtained from the equations 4.1 and 4.2.

D = (t1 - t0) / T0 = (t3 – t2) / T0 … (3.1)

1 - D = (t2 - t1)/ T0 = (t4 – t3) / T0 … (3.2)

Advantages of Dual bridge topology over ConventionalMethods
The following are the advantages of Dual bridge topology over the conventional methods.
_ No dead time.
_ One power transformer and no magnetic tapping on the primary winding.
_ significantly reduced input current ripple.
_ significantly reduced output filter inductance value, thus inductor size.
_ Less stress on switching components.
_ Self – Driven synchronous rectifiers can be used as output rectifiers to increase the
Power efficiency of the converter.
_ The ZVS dual bridge DC – DC converter is implemented by fixed frequency PWM
Control without using phase – modulated control.

4. BLOCK DIAGRAM AND ITS BRIEF DESCRIPTION

The block diagram and its brief description of the project work "MICROCONTROLLER BASED PROGRAMMABLE DC - DC CONVERTER" is explained in thischapter. The main block diagram, which is shown at the end of this chapter, consistsfollowing blocks.

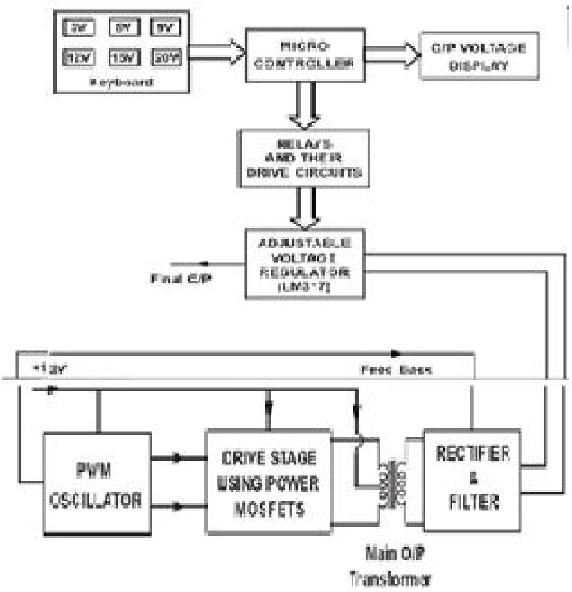

Fig: 4.1 block diagram for micro controller based programmable dc - dc converter

DC- DC Converters – An Overview
Many Industrial drives and processes take power from DC voltage sources. In mostcases, conversion of DC source voltage to different levels is required. For example, Bus,Train, Ship, Flight, etc; Generally these kind of huge traveling bodies are equipped with hugebatteries, and with the help of this DC – DC Converter, different DC levels are generated toenergize various electronics equipment's. There

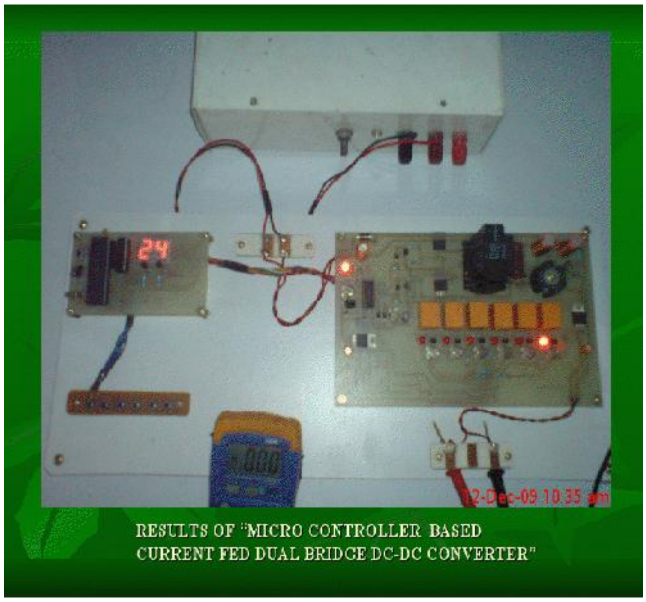

Fig: 4.2 Hardware implementation of "Micro controller based current fed dual bridge dc-dc converter"

is a need to energize electrical devices likeTube light, cooler, etc.; for which AC voltage is required and with the help of an inverterconnected to a fixed DC source as input source, the required AC voltage can be generated.Weather it is a Inverter or Converter, the input source is DC, and generates different DClevels or from DC to AC source to energize various Electrical and Electronic devices belongsto these traveling bodies.

Many Industries (manufacturers of DC – DC converters) offering high powerconverters up to 1000W. Using high switching frequency, hybrid circuit, chip-on-board andsurface mounting technologies, these DC-DC converters provide high power density, a lowprofile and high efficiency. Accurate current sharing and fixed frequency synchronization ofDC-DC converters allows reliable parallel operation for easy expansion. The product linecovers commercial, industrial and military grade applications.

SIMULATION RESULTS

5. Simulation of Current Fed Full bridge DC-DC converter

Simulation circuit for current fed ful bridge DC-DC converter is shown in fig: 5.1

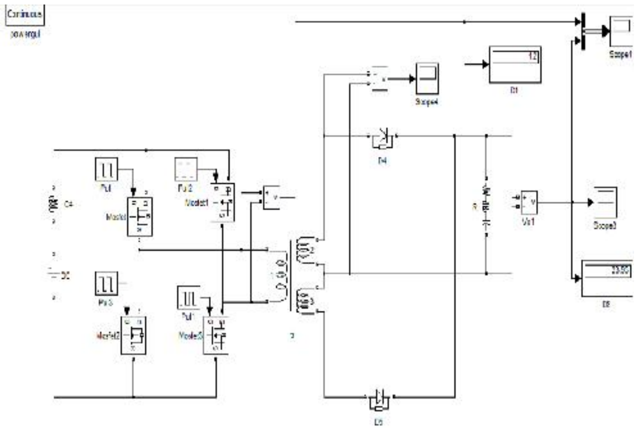

Fig: 5.1 Current-Fed Full Bridge DC-DC Converter

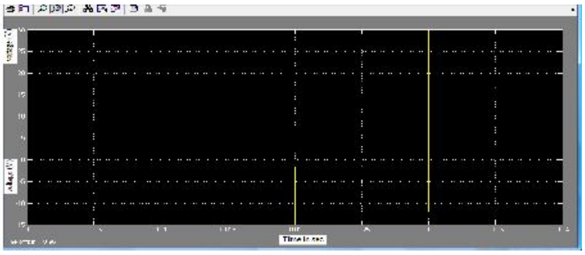

Fig: 5.2 input and Output Voltage Waveforms

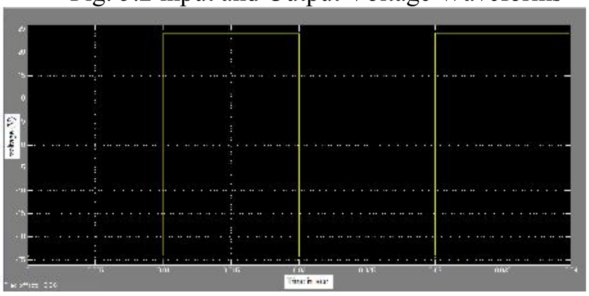

Fig: 5.3 Transformer & Secondary Waveforms

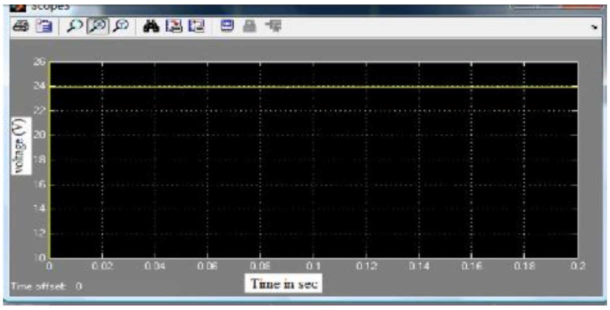

Fig: 5.4Output Voltage Waveform

The simulation was done for conventional half bridge and Full bridge DC-DCconverter and Dual Bridge Converter systems. The simulation results are presented. Fourierspectrum was obtained for Conventional circuit and Dual Bridge circuit. From the frequencyspectrum it is observed that the Dual bridge DC-DC converter produces lesser harmonicscompared to the conventional converter. Significantly reduced input current ripple.

6. Simulation of Current Fed Dual bridge DC-DC converter

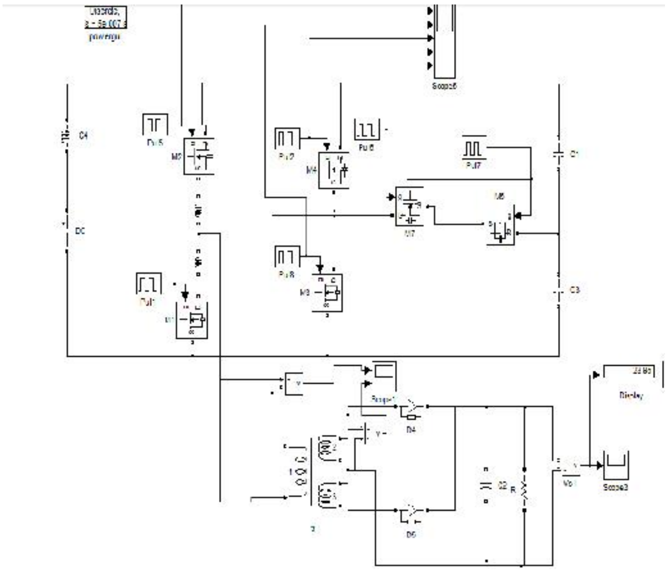

Fig: 6.1Current-Fed Dual-Bridge DC-DC Converter

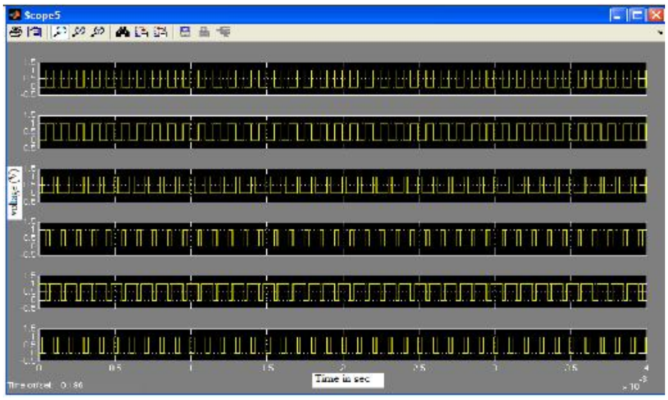

Fig: 6.2 Switching Pulses for M1, M2, M3, M4, M5, M6

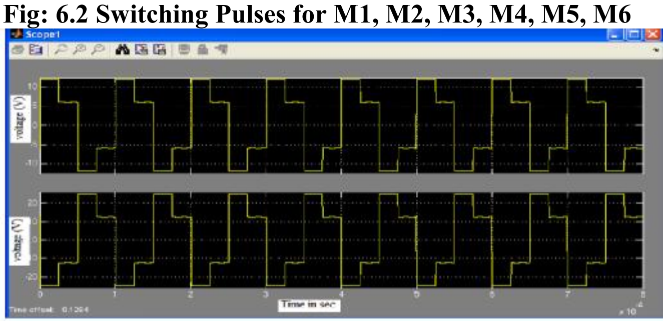

Fig: 6.3 Transformer Primary & Secondary Waveforms

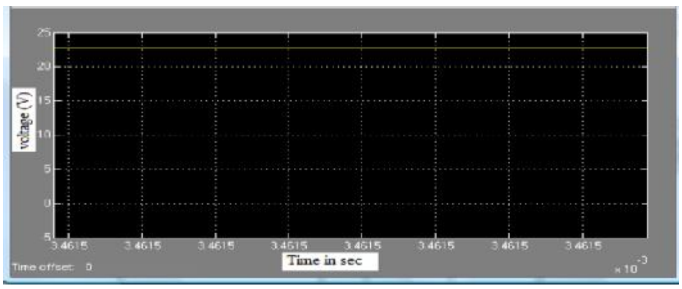

Fig: 6.4 Output Voltage Waveform

7. CONCLUSION

The topologies Dual Bridge DC – DC Converter have been described with modesof operation and ideal waveforms. The circuits have been analyzed. The simulation was donefor conventional Full bridge DC-DC converter and Dual Bridge Converter systems. Thesimulation results are presented. Fourier spectrum was obtained for Conventional circuit andDual Bridge circuit. From the frequency spectrum it is observed that the Dual Bridge DC-DCConverter produces lesser harmonics compared to the conventional converter.The timing sequence of control signals, transformer primary voltage with no deadtime operation and simulation results are given by IEEE transactions on Power Electronics,Vol.19, No.1, January 2004 by Wei Song and Brad Lehman. The Dual Bridge DC-DCConverter for R load was implemented. The various stages of the control and main circuitsare presented with all specifications. The output waveforms obtained at different stages arepresented. The experimental results coincide with the simulation results.This project work "MICRO CONTROLLER BASED PROGRAMMABLE DC-DCCONVERTER" is successfully designed developed tested and a prototype Module isfabricated for the demonstration purpose. Since it is a prototype module, the converter outputcurrent is limited to 500 milli amps, but for the various practical applications this current canbe increased. The converter is designed to operate at 12V DC, for this purpose 12V lead acidbattery can be used as input source and solar energy can be utilized for charging the battery.For the demonstration purpose 6 different DC levels are designed, in case if requiredmore outputs can be derived from the same converter. Similarly the output voltages also canbe programmed according to the one's requirement. This type of designs is very well suitedfor field applications where the domestic power is not available.

The advantage of PWM IC based converters is compact in design, easy for maintenance and troubleshooting. To increase the power handling capacity, higher rating MOSFETS can be used with a suitable main output transformer. In this project work, for programming the desired output microcontroller chip is used for selecting the channel as well as for displaying the channel voltage. The same controller also can be used for displaying the channel current. For thispurpose, current transformer can be used and its primary can be connected in series with theload. The current flowing through CT primary can be measured and displayed with little modifications in the hardware and software.

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9. APPENDIX

HARDWARE DETAILS

The IC's and other important components used in this project work, procured from theHyderabad Electronics Market. The details or data sheets of the IC's are down loaded from theInternet. The following are the web sites that can be browsed for collecting the data sheets._
www. Texas Instruments.com_
www. National semiconductors.com
www. Fairchild semiconductors.com
The following are the IC's and other important components used in this project work
(1) 89C51 Microcontroller Chip
(2) 74LS573 Latch
(3) SGS 3524 PWM IC
(4) LM 317 3-Terminal Adjustable Regulator
(5) Voltage Regulator
(6) Z44 Power MOSFETS
(7) Relay
(8) BC 547
The required PCB'S (Printed Circuit boards) for the project work fabricated by SUNRISE CIRCUITS, Kushaiguda Industrial Estate, Hyderabad. Kushaiguda Industrial Estate isvery famous for fabricating the Industrial grade PCB's.

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